LBNE Simulations Issues and Needs

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- Beam – See Paul's Talk
- Far Detector
- Near Detector
- Cosmogenics
- Radiologicals

LBNE Far Detector Simulation Issues

We use LArSoft, based on the ART framework.

Simulations have been developed for ArgoNeuT and MicroBooNE.

ArgoNeuT simulations validated with data.

Detector response is largely handled by LArSoft stepping code:

ionization electron drift is parameterized using our own recombination parameterization, drift velocity, and Gaussian diffusion terms.
Photon yield also parameterized. NEST parameterization included, as well as older parameterizations.

Too many electrons to simulate one by one – tens of thousands per MeV of energy loss
Assigning of charge to wires and signal shaping done by LArSoft, not G4

LBNE Far Detector Simulation Issues

Too many photons to propagate using G4 – also tens of thousands/MeV

Photon propagation lookup libraries:

Probability(photon sensor channel | Photon production location) filled with G4 simulation of each photon, or with an analytic model

Libraries can be very large (hundreds of MB) and need to be distribute to grid jobs and loaded into memory.

Geometry: 10 kt detector has 310 K wires and of order 1200 photon detectors
Underground – longer drift length – fewer channels needed (but not that much).

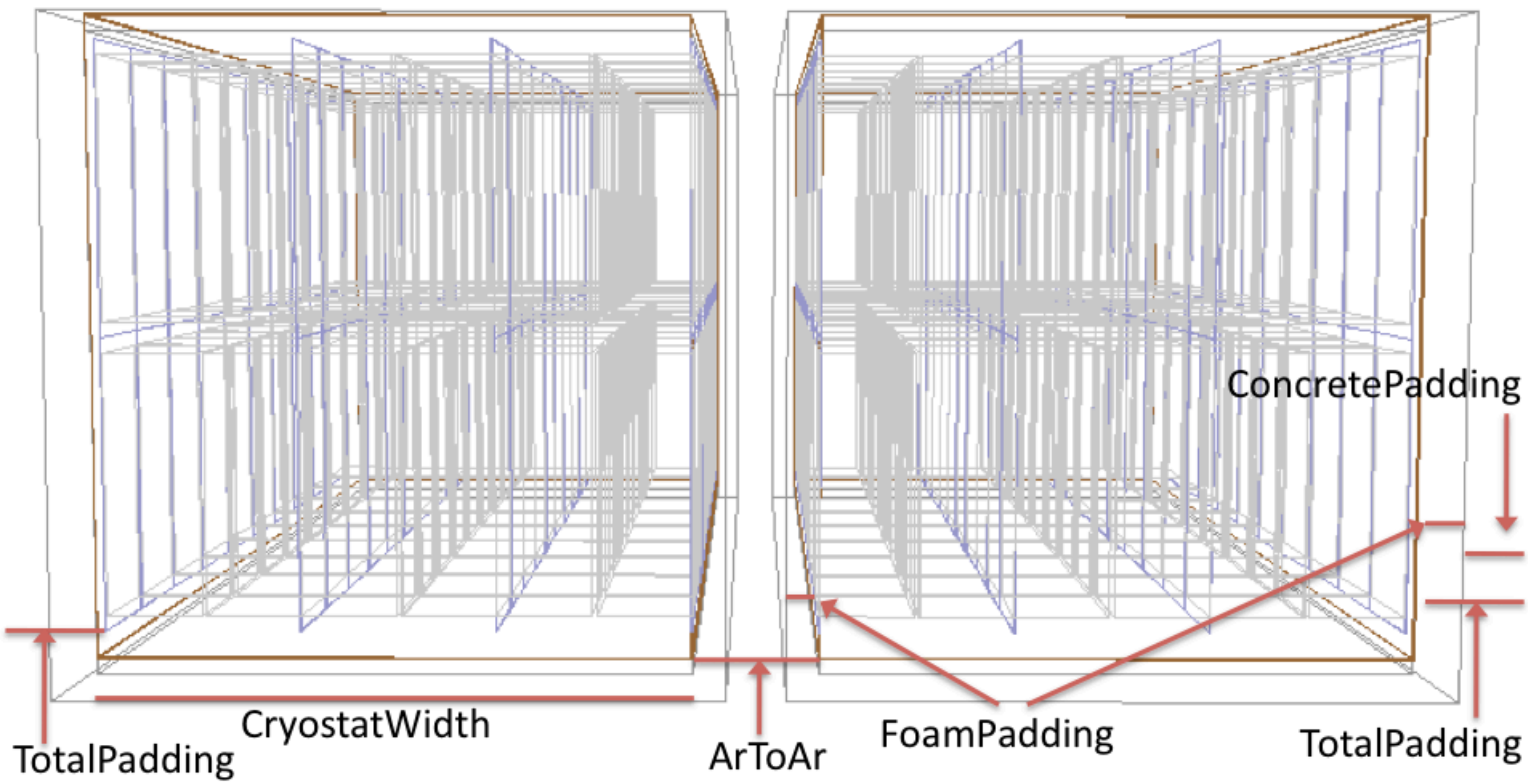
More channels will be needed if we go for 36 degree wires (fewer wraps)

Project would like full simulation and reconstruction to motivate design choices. Not yet mature enough for much of this, but we can explore changes with the algorithms we have.

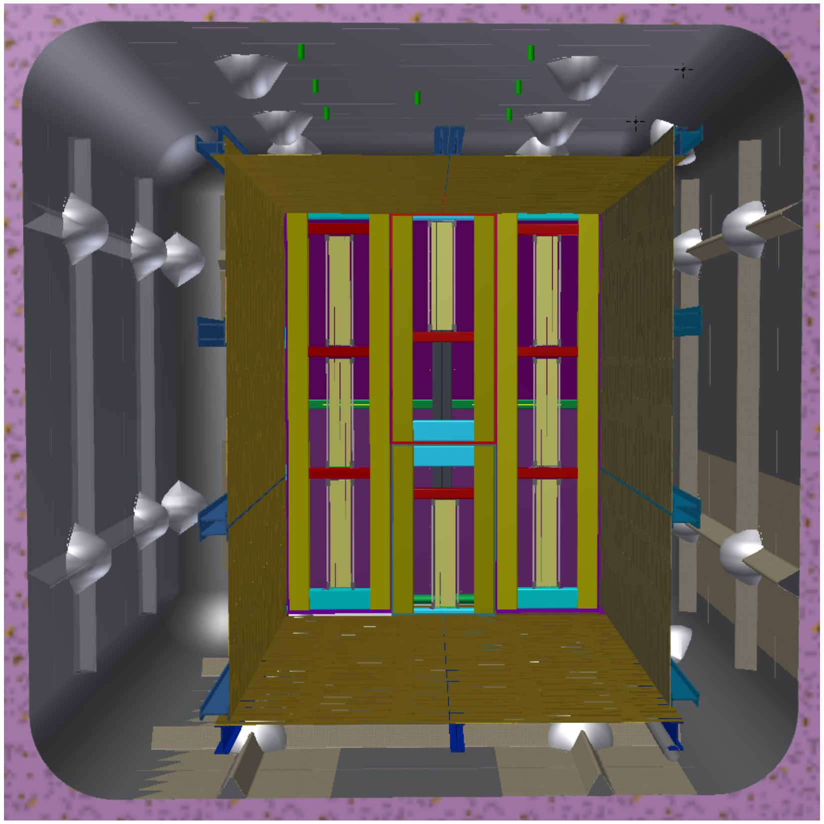
10 kt Realistic Surface FD Geometry in LArSoft (GEANT4)

Other versions:

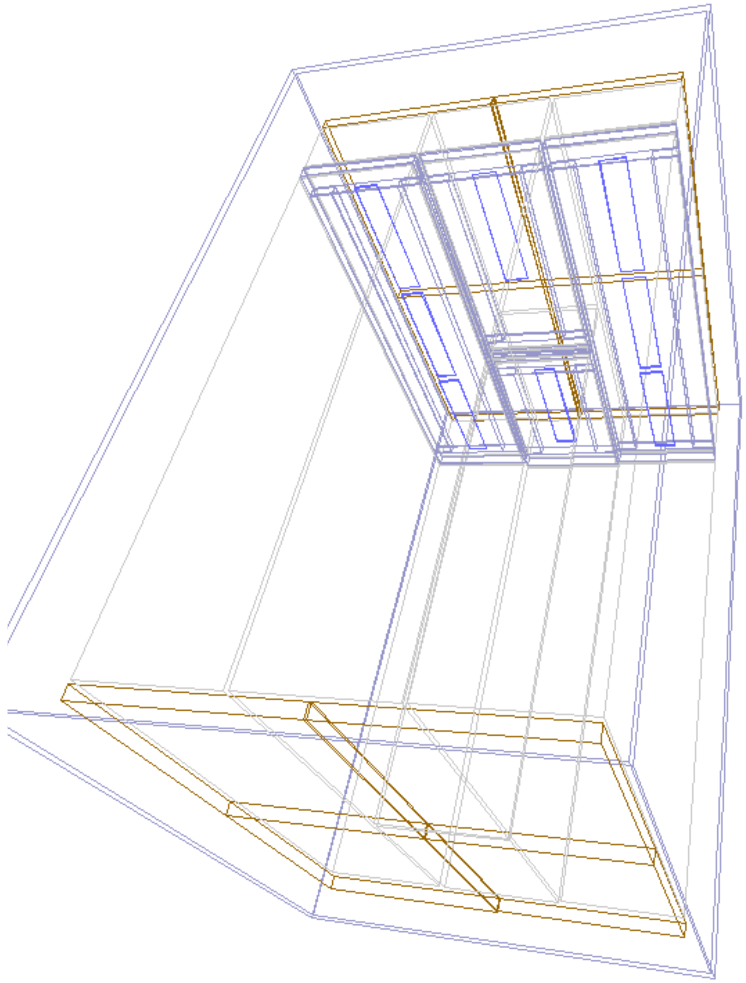
- 34 kt Underground Geometry
- 4-APA reduced geometry for prototyping code
- All with 45° and 36° induction-plane wire angle versions



Updated 35 t Prototype Geometry in LArSoft



Engineering Drawing



FD Geometry Issues

Geometry is modeled in GDML, made with Perl scripts, modified from MicroBooNE versions.

Relatively compact – couple of MB per geometry description file.

Not compact in RAM – when a FD job starts, it takes almost 2 GB of virtual size before the first G4 step. This is geometry related since a 35t job takes 800 MB all told, and it's the same code.

Physics Simulation Issues

Mostly GENIE tuning.
We will be embarking on a program of understanding dE/dx performance in 35t but do not yet have the data.
NEST modeling currently agrees with expectations for photon and electron yield, but we need to run it with very small steps.
Space Charge – drift field modified. How to measure?
Calibration response – laser ionization of liquid argon
Tuning LArSoft/GEANT to LArIAT Data, with systematic uncertainties – this is the mechanism we expect for LArIAT to contribute to LBNE.

ND Simulation

Need People!   We have a parameterized Fast Monte Carlo

We had been seeking international contributions, but realize now that U.S. participation in design and simulation effort is critical.

Would like to share code and expertise with the FD so that collaborators can easily shift from FD to ND.

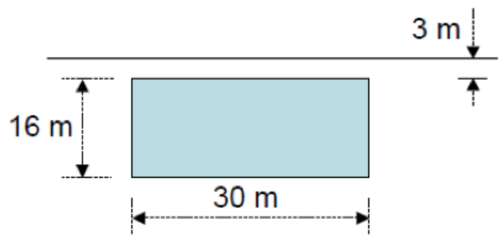
Technology choice – support for a straw tube tracker with surrounding ECAL. Do we need liquid argon in order to cancel systematics to the level we need?

People prefer a definite design before committing large effort.

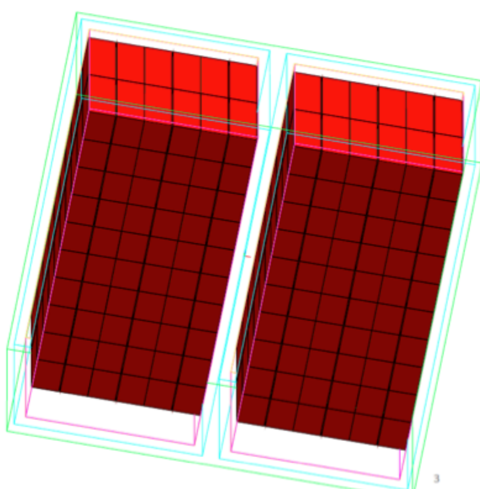
Cosmogenics

Great work done by Vitaly Kudryavtsev, Jeff De Jong, Martin Richardson, Dongming Mei, Karl Warburton, Chao Zhang, Franco La Zia

Simplified FD geometry: rectangular prism (now split up into APA volumes):



- **8.1 m w. e. depth, flat surface. In fact the overburden will be bigger but this does not affect much muon background**
- **$30 \times 15 \times 16$ m^3 detector, total mass – about 10 kt.**



- **Two cryostats, each split into 120 cells, each with an active volume of $224.5 \times 226.8 \times 630$ cm^3.**
- **Total active mass of 10.7 ktons.**
- **0.5 m concrete enclosing cryostats.**
- **0.8 m fibre glass surrounding cryostats.**
- **3 m concrete between cryostats.**
- **0.5 inch stainless steel vessel.**
- **Already used in some previous simulations.**

Cosmogenic Simulation Issues

Backgrounds on the surface are copious but most events are easily rejectable.

Large numbers of cosmics needed to simulate rare processes. Currently backgrounds to ν_e appearance analysis investigated on the surface.

- spallation from cosmics outside the active volume
  Neutrons and other neutral particles entering and initiating showers
- Electromagnetic showers initiated by muons
- Cuts devised to reject showers from identifiable muons.
- Need signal efficiency after background rejection cuts – expect it to be high.

Underground physics has different needs:

Atmospherics
Nucleon Decay – specifically kaon production in atmospheric neutrino scatters.
Cosmics passing outside the active volume (even in the rock) generating neutrals that can fake nucleon decay
Supernova neutrino interactions – very low-energy electrons.

Radiological Simulation Issues

14k ^{39}Ar decays in each 2.5 ms drift window.
Efficiency – we do this ourselves without G4 steps.

Materials can be activated by cosmics (surface problem, less of an issue underground).

An issue – photon detector acceptance for a low-energy supernova neutrino electron may be only 1 or 2 photoelectrons.

Radiological backgrounds in the
materials near the photon detector paddles may keep us from using the photon detectors to time them in.